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ABSTRACT

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CAI CENTER

TECH MEMO

AN INVESTIGATION OF THE EFFECTS OF TWO TYPES OF INSTRUCTIONAL TERMINALS IN COMPUTER-MANAGED INSTRUCTION

Bobby R. Brown, Wallace H. Hannum, and Walter Dick

Tech Memo No. 36
May 15, 1971

Project NR 154-280
Sponsored by
Personnel & Training Research Program
Psychological Sciences Division
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Arlington, Virginia
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FLORIDA STATE UNIVERSITY

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Duncan N. Hansen
Director
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ABSTRACT-continued

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One of the most often suggested ways to improve education is that of individualizing the instructional process to more adequately meet the needs of each student. The problem of individualizing instruction has intrigued educators for several decades. Early attempts at individualization were reported by Washburne (1926), and Parkhurst (1922). Although these plans were well formulated, progress in the implementation of individualized instructional programs has been meager.

This lack of progress is, in part, a function of administrative problems associated with individualized instructional programs. In a truly individualized program, all students in a class would pursue different instructional sequences, at varying rates, which places a management burden upon the teacher. Recording the progress of each student, and prescribing instruction for him is a task which can require a large amount of time from several persons. The work with individually prescribed instruction (IPI) done at Oakleaf School in conjunction with the University of Pittsburgh demonstrated the magnitude of the problem of non-automated information management (Cooley and Glaser, 1969). Initially, the IPI program used several clerical assistants to aid teachers in the handling of the information necessary for the management of such an instructional system.

There have been several recent attempts at applying computer technology to the managerial problem underlying individualized instruction programs (Coulson, 1968; Schuer, 1967; Flanagan, 1970; Hagerty, 1970). Although these studies differ in a variety of ways, they are all sufficiently similar to be labeled computer-managed instruction (CMI) projects (Morgan, 1969).

In CMI, the computer can function as evaluator, diagnostician, and prescriber of instruction as well as a recorder of student progress. Rather than serving as our instructional presentation service as in computer-assisted instruction (CAI), the computer monitors the student's learning through a step-by-step evaluation of his progress. Thus in CMI, the actual learning does not occur at the computer terminal, but rather "off-line" in a more conventional (but usually individualized) fashion. Since on-line instruction is not a feature of CMI, the computer costs of this approach are much lower than CAI. Hagerty (1970) reports a comparison of the costs of instruction between CMI and traditional instruction at the University level. She found that CMI costs were approximately one-half to one-third the cost of conventional graduate instruction.

There are two basic types of CMI systems: batched processing and terminal oriented. There are a number of projects which have utilized a batched processing system in their operations such as Flanagan's Project Plan (1970), Coulson's work at Systems Development Corporation (1968), and O'Dierno's (1969) work at the New York Institute of Technology. In these projects, students are directed to learning materials based on progress information supplied by the computer to their teacher. Students' instruction and testing is all performed with conventional paper and pencil procedures. Test answer sheets are read by optical scanners and the data is transferred to computers for analysis and reporting. In turn, the reports are supplied to the instructor and/or the student.

A terminal-oriented CMI system has been developed at the Florida State University CAI Center. The significant feature of this interactive CMI approach is that the diagnostic evaluations and learning prescriptions take place in real-time via an interaction between the student and the computer system. This system has the virtue of providing immediate corrective feedback as opposed to the usual 1-2 day wait in the batched systems.

The initial implementation of this interactive system has been reported by Hagerty (1970) and Gallagher (1970). The present study extends the investigation of an interactive CMI system by focusing on the use of two different terminal devices for the student-machine interface. The terminal devices used were cathode-ray tubes (CRT) and teletypes (TTY). Information can be displayed at a faster rate on the TV-like screen of the CRT as compared to the typing rate of the teletypes, but the CRT's do not provide a hardcopy of this information for future reference. Due to the presentation rate, the CRT's may be more efficient terminal devices than teletypes for use in an interactive CMI system. However, the teletypes generate a printout of the student's interaction with the system which can be used for future study and review. Thus, the teletypes might be considered the more desirable terminal device in terms of fostering student learning and retention.

The major purpose of this study was to investigate the performance of students in a CMI course when they used two types of terminal devices. The role of individual differences with regard to terminal device was also investigated. A study by Dick and Latta (1969) reported a significant ability by treatment interaction in a comparison of programmed instruction and CRT-oriented CAI instruction. They found that low ability junior high school students performed better on PI than CAI, whereas there were no differences for high ability students. They tendered the explanation that low ability students may be unable to cope with the information load from the CRT since they don't have a copy of previous information to assist them. In the current study, graduate record exam (GRE) and gradepoint average (GPA) were used as indices of graduate student ability.

STATEMENT OF THE PROBLEM

This investigation examined the effect of two different terminal devices (CRT and teletype) on both performance and time required to complete a graduate level course offered via an interactive computer-managed instruction system.

In investigating differences due to terminal device, several indices of student performance were used. These include: (1) Student scores on a criterion-referenced test of the major objectives involved in the course; (2) Instructor rating of each student's project for the course which included the development of a unit of programmed instruction and accompanying documentation; and (3) Time spent at the CMI terminal.

In addition to these three primary indices, serveral other measures were obtained. These include the error rate on performance on the computer terminal, the number of objectives in which criterion performance was not initially reached, and the computer costs per student for participating in the course.

SUBJECTS

The subjects for this study consisted of 28 graduate students who enrolled for the course "Techniques of Programmed Instruction" in the Department of Educational Research at the Florida State University during the Spring Quarter, 1970. There were 4 females and 24 male subjects. The subjects were randomly assigned to either CRT or teletype terminals.

APPARATUS

An IBM 1500 Instructional System was used to conduct this study. The IBM 1500 Instructional Display terminal equipped with light pen and typewriter keyboard served as one terminal device. The other terminal device used was a teletype. The addition of a DEC 680 System under the control of a PDP/8 Computer provides the capability to drive both CRT's and teletypes by the same system.

MATERIALS AND PROGRAM DESCRIPTION

The materials used in this study consisted of a course guide distributed to the students at the start of the course, and numerous articles and chapters in books that were referenced to specific course objectives. The course guide included a task analysis of the course (see Appendix A), and for each task the guide gave the overall goal, specific behavioral objective(s), a sample test item, and primary and secondary references. These references were reproduced and kept in the Center's library which was open daily for student use. For each behavioral objective, approximately fifteen test items were written and entered into a test item pool in the CMI system.

The CMI system was programmed in Coursewriter II, the CAI language which is available for the IBM 1500 CAI System. The functions of the CAI system consisted of record keeping, testing, diagnosis of weakness, and remediation. The student was not presented actual instructional materials on the terminals. A flow diagram of this interactive system for one unit in the course in presented in Figure 1.

This figure represents the path followed within each unit of the course. The first 12 tasks covered the concepts involved in the preparation of programmed instruction, the last 8 tasks involved the students' preparation of their own programmed unit and the documentation for it. The unit tests for each of the first 12 units consisted of 5 multiple choice or true-false questions selected at random from the test item pool for each objective for the task. The criterion for these task tests was set at 80% or 4 our of 5 items for each objective.

The tests for the productive portion of the course, tasks 13-20, consisted of a series of questions that the instructor would have asked the student about his product. It is possible to regard these tests as a simulated interview between student and instructor in which the instructor asks the student yes or no type questions about what he has done.

PROCEDURES

The treatment period for this investigation was ten weeks, the length of the Spring academic quarter at Florida State University. At the first meeting of the class, the procedures for the course were described.

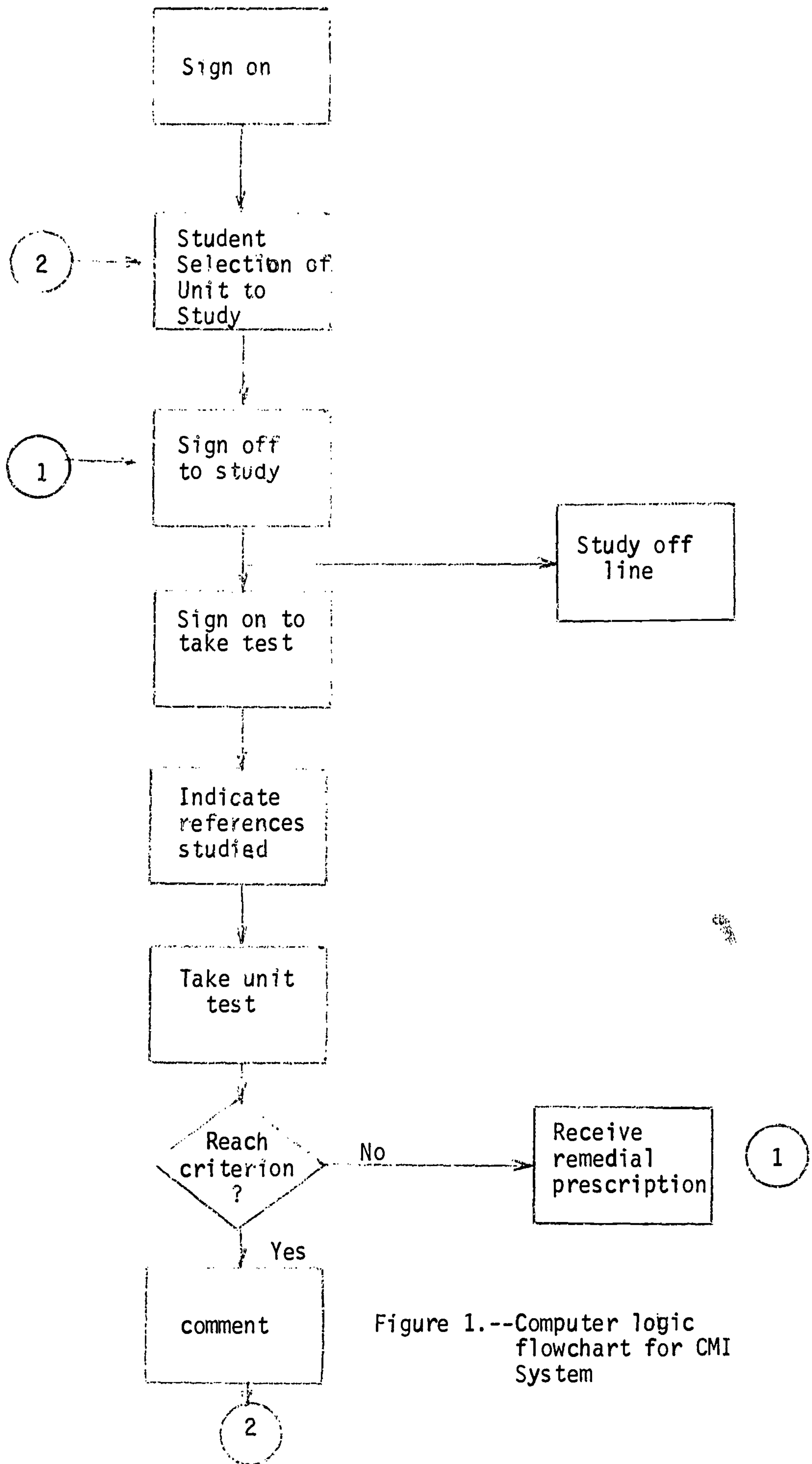

Figure 1.--Computer logic flowchart for CMI System

The students were told how they would procede through the course via computer management and were given a copy of the course guide. During this class they were told that they would not meet again until the last day of the quarter when their product for the course was due.

The students were allowed to complete the units of the course in any order they desired at any rate they wished, with the restriction that they must finish all the units and complete their product by the end of the quarter. When a student completed the first 12 units covering the concepts involved in programmed instruction, he was given a paper and pencil examination designed to measure his knowledge of the concepts (see Appendix B). When the student had turned in their programmed instruction documentation, a score was assigned to this product using an instructor rating sheet (see Appendix C).

The class met briefly the last day of the quarter primarily to discuss their reactions to the course, any problems they encountered, and to provide some closure for the course. It should be noted that the class only met on the first and last days of the quarter. They were required to finish the first 12 tasks by midterm and to have the documentation finished by the end of the quarter.

RESULTS

The main focus of this study was the investigation of the effect of two different terminal devices on student performance in a course offered via an interactive CMI system. The primary indices of studnet performance were scores on the final test over the conceptual tasks, scores on the course project (development and documentation of PI text), and total time spent by each student at the computer terminal.

Table 1 presents the means and standard deviations for the two experimental groups on these three performance indices.

TABLE 1

Performance in CMI Course by Students Using Different Terminal Devices

Groups		Concept Test	Product Evaluation	Time (Min.)
CRT	Mean	90.64	52.00	261.14
N = --	Standard Dev.	7.15	6.13	329.43
TT	Mean	89.86	45.36	353.78
N = --	Standard Dev.	8.06	5.87	327.84
TOTAL	Mean	90.25	48.83	307.46
N = --	Standard Dev.	7.49	6.78	325.92

It can be readily seen from the data in Table 1 that both groups performed equally well on the test over the concepts involved in the course. The CRT group had superioe scores on the course project and spent less time actually working at a terminal.

In order to evaluate the differences on the concept test, an analysis of covariance was performed using the biomedical general linear hypothesis program (Dixon, 1968). The results of this analysis using pretest scores for the covariant yielded a F-ratio of 1.52. The F-ratio obtained from this analysis is not significant at the .05 confidence level. This indicates that there were no differences in the posttest over the concepts when the scores were adjusted for pretest differences.

An one-way analysis of variance was performed on the scores on the course product to examine differences between the two groups. This analysis is presented in Table 2.

TABLE 2

Analysis of Variance for Product Scores

Source	Sum of Squares	of	Mean Squares	F
Between	252.7589	1	252.7589	6.99
Within	758.5455	21	36.1212	
Total	1011.3043	22		

The obtained F-ratio is significant at the .05 level. The products of the CRT group were rated as significantly superior to the products of the teletype group.

In order to evaluate the differences between the two groups in the amount of time spent on the computer terminal a Mann-Whitney U statistic was calculated. This resulted in a U of 33, significant at the .02 level indicating that the CRT group spent significantly less time signed on to the computer during this study.

In addition to these main analyses. several supplemental factors including the number of errors on the unit tests, the number of times criterion performance was not reached on the first attempt, and the costs associated with the use of the two terminals was investigated. Table 3 shows the comparison between the two groups on these factors.

TABLE 3

Mean Errors, Criterion Failures, and Associated Costs

	Mean Errors	Mean Failure to Achieve Criterion	Computer Costs per Student
CRT	37.21 13.23	5.14 1.99	$14.48
TT	33.71 19.08	5.07 1.49	$19.58

The total number of task test errors was not significantly different for the two groups. There was also no difference in the number of tasks on which criterion performance was not reached on the first attempt. The analysis of the cost per student indicates that the teletype was the more expensive terminal device. These cost figures were computed by multiplying the number of student hours spent on the system by the figure that reflects the current cost for time at the FSU CAI Center. This figure is $3.33 per student per hour regardless of terminal device. If the actual costs of the terminal devices were included, the teletype groups' costs would be even lower.

The general finding was that, regardless of terminal device, students perform equally well on the test on conceptual material. However, the CRT group spent less time interacting with the computer and also developed better course projects.

In order to access the role of individual differences within this CMI system, several indices of individual differences were employed: (1) GRE total scores; (2) grade-point average (GPA); and (3) anxiety as measured by the State Trait Anxiety Inventory (Spielberger, Gorsuch, and Lushene, 1968). The correlations between these variables and the performance variables are presented below in Table 4.

TABLE 4

Relation Between Performance Measures and Individual Difference Variables

	GRE	GPA	Anxiety
Midterm Test	.11	.20	-.07
Product grade	.13	.38	.15
Number of Failures to Achieve Criterion	-.01	-.67*	.38

*p < .05

The only significant coefficient in this table is the correlation between GPA and the number of times criterion performance was not initially reached in the course evaluations on the terminals. This correlation would indicate that persons with higher ability as measured by GPA tended to more often reach criterion performance on the first attempt.

The GRE scores were not related to any of the performance measures in the course. The anxiety scale also was not significantly correlated with performance. There was no evidence of differential performance of students of differing abilities.

DISCUSSION

Results from the analysis of the concept test reveal that students perform equally well regardless of terminal device. Apparently the information load in the CMI system is sufficiently low to allow acceptable performance without the necessity for some form of memory support. The difference in error rate is interpreted to reveal a diminished effect of memory support on reducing errors. This effect of memory support has been found in CRT's using CAI learning materials. The failure to find this effect in this study is probably due to the difference in CMI and CAI, i.e., CMI does not present instructional material that may require some form of memory aid for effective learning.

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As was expected the CRT group spent significantly less time signed on to the CMI system. This probably reflects the operating speeds of the terminal devices rather than any other factor.

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APPENDIX A

——— cognitive unit
- - - productive unit
-·-·- cognitive and productive units concurrently

20 Produce a document describing Systems Analysis development and standardized evaluation of a Programmed Instruction text.

19 Document the PI text you have written

18 Execute and Document the Summative Evaluation

17 Conduct the Formative Evaluation and Revise materials

Write PI course of instruction based on task analysis, behavioral objectives, entry behavior and instructional strategy selected

Develop the formative evaluation plan

Develop summative evaluation plan using standardized procedures

Select appropriate strategy of presentation for area of instruction

11 Write test items for each B.O.

12 Distinguish formative & summative evaluation

Describe the use of Systems Analysis in developing materials for a medium other than PI

Distinguish strategies available with PI

9 Classify B.O. in terms of the tasks required of the learner

6 Identify types of PI frames

7 Identify behavioral objectives which have been written correctly

Distinguish PI and non-PI

4 List requirements for task analysis

5 Identify entry behavior of students

2 List requirements for choosing an area of instruction

1 Identify and describe components of the Systems Approach

Task Analysis of Techniques of Programmed Instruction, showing cognitive and productive units.

APPENDIX B

MIDTERM EXAMINATION FOR PROGRAMMED INSTRUCTION COURSE

This examination covers the thirteen cognitive units of the programmed instruction course. Read and answer all questions carefully.

1. Briefly explain the major use of the Systems Approach in Education.

2. List, in order, the steps in Dick's or Hansen's Systems Approach Model.

3. List the three elements basic to all Systems Approach Models.

4. List five of the basic requirements necessary in choosing a subject matter area to be programmed.

5. Briefly define:

   a. Step size--
   b. Explicit response--
   c. Feedback--
   d. Prompt--

6. Name three characteristics that differentiate programmed instruction material from non-programmed material.

7. Define task analysis in reference to instructional design.

8. Briefly define what is meant by entry behavior (give examples).

9. Briefly define:

   a. Baboon frame--
   b. Discrimination frame--
   c. Confirmation frame--
   d. Sub-terminal frame--

10. A well written behavioral objective contains:

11. List and briefly define Gagne's eight levels of learning.

12. Briefly define:

    a. Adjunct programming--
    b. Extrinsic programming--
    c. Intrinsic programming--
    d. Linear programming--

13. List at least two programming strategies and reasons for selecting each.

14. List and define at least four types of test items.

15. List five characteristics of a well-written test item.

16. Briefly differentiate between formative and summative evaluation.

17. List the differences between using the Systems Approach in developing materials for programmed instruction and materials for any other medium.

****

APPENDIX C

537 PROJECTION EVALUATION SHEET

STUDENT NAME__________
CMI #__________
EVALUATOR__________

Topic Area__________

Expert__________

(10) 1. Task Analysis (5) _____

Reasonable sequence (5)

(10) 2. Behavioral Objectives (5) _____

Well written, compared with TA (5)

a. Comparison with conventional curricula _____
b. Outline of contents of program _____
c. Show limits of the program's objectives and areas not being developed by the program _____

(5) 3. Description of Entry Behaviors (3) _____

How derived, expressed as entry behavior and skills (2)

(5) 4. General Description of Target Population (5) _____

Not entry behavior

a. Minimum grade on standardized ability or aptitude tests _____

(10) 5. Program Preparation (Description of preparation process) (10) _____

Select strategy, use TA, entry behaviors, etc.

a. Expert Opinion _____
b. Revision based on one-on-one _____

(10) 6. Evaluation Plan (Preparation for evaluation, data collection and development of instruments) and report of data (error rate of program and testing) (10) _____

(10) 7. Revision Suggestions or Implications (10) Based on Report of Data in #6 _____

(5) 8. Miscellaneous (General overall impressions) (10) _____

a. Indications of student attitude _____
b. Practicality of program, e.g., supplemental materials, reuseability, maintenance costs, etc. _____
c. Administration, e.g., conditions necessary for success, procedures forintroducing students to the program, etc. _____

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